Mini-LANNDD T40

A detector to measure the neutrino-argon cross section and the ν_e contamination as a near detector in the on-axis/off-axis NuMI beam or/and on the MiniBooNE beamline at FNAL

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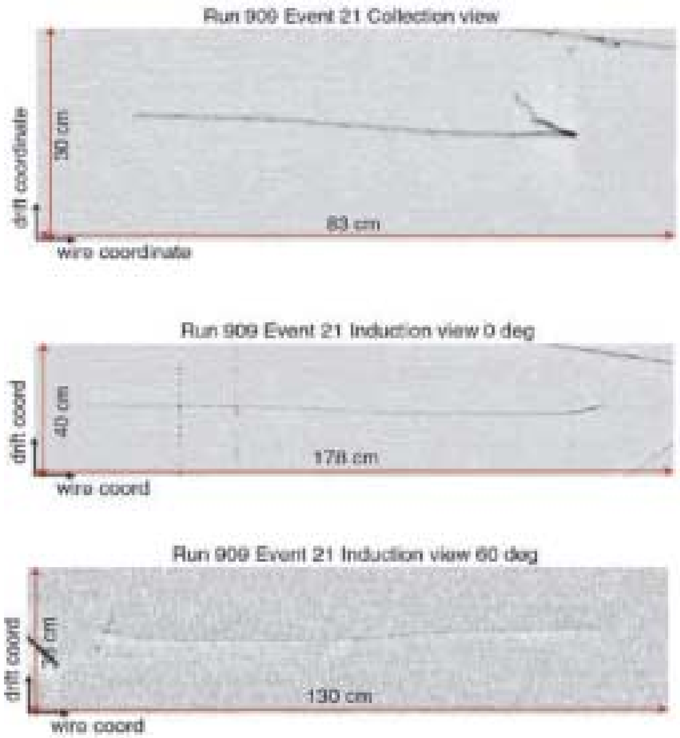
The Storyline

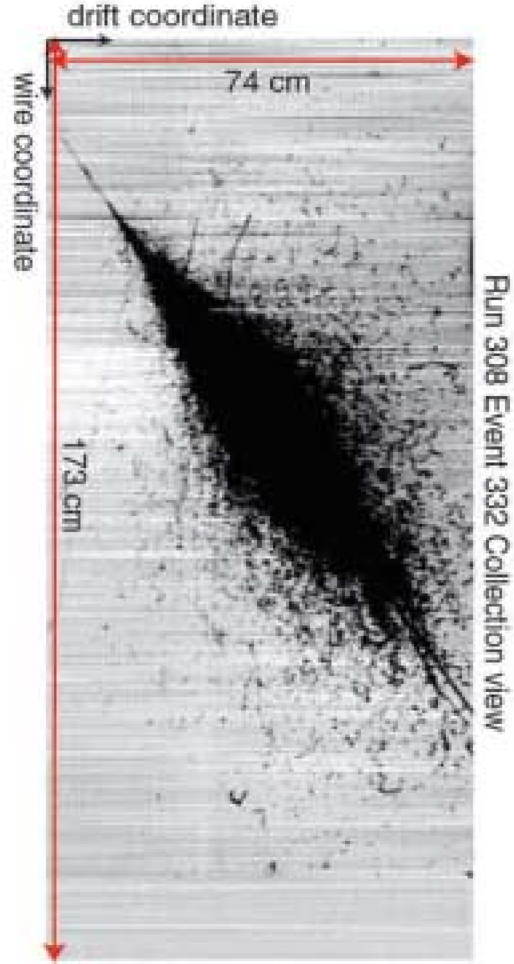
- **A large size (~300 ton) Liquid Argon TPC and Calorimeter in Operation – ICARUS T600 and BARS**
  - **ICARUS: Ready to go to Hall B at Gran Sasso, Italy.**
  - **BARS: In operation from 1996**
- **LANNDD - Liquid Argon Neutrino and Nucleon Decay Detector**
  - **A large mass (up to ~100 kTon) magnetized TPC possibly located in USA in superbeam from future BNL or FNAL neutrino factory.**
  - **See K. McDonald's talk for more details**
- **Mini-LANNDD T40**
  - **A detector that will measure ν_e contamination in on-axis/off-axis NuMI beam as a near detector or/and on the MiniBooNE beamline.**
- **Concluding remarks**

ICARUS T600 Test Runs in Pavia

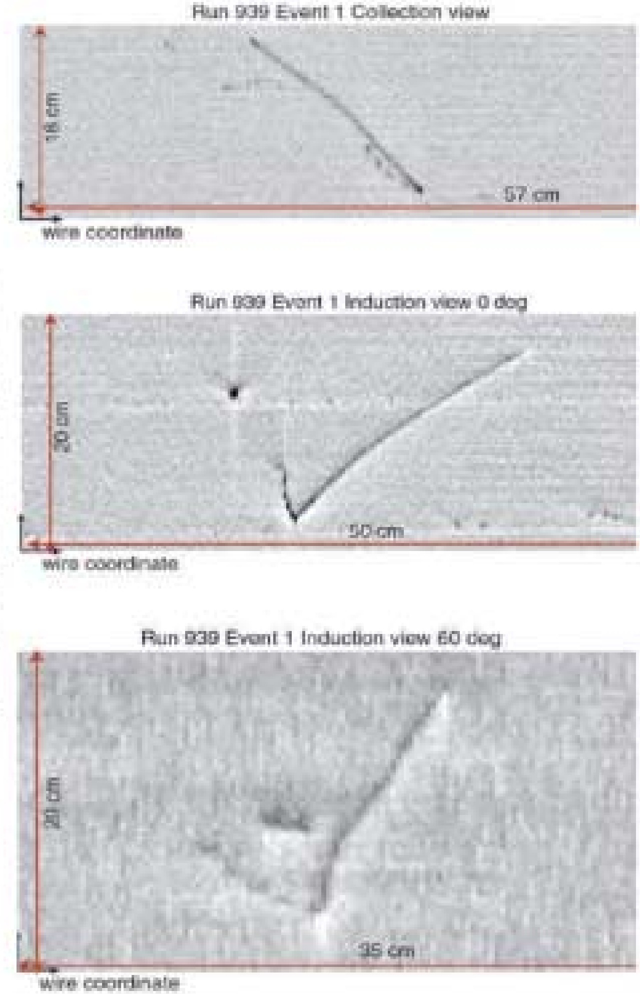
http://www.aquila.infn.it:80/icarus/index.html



Stopping muon decaying into electron (3 views)

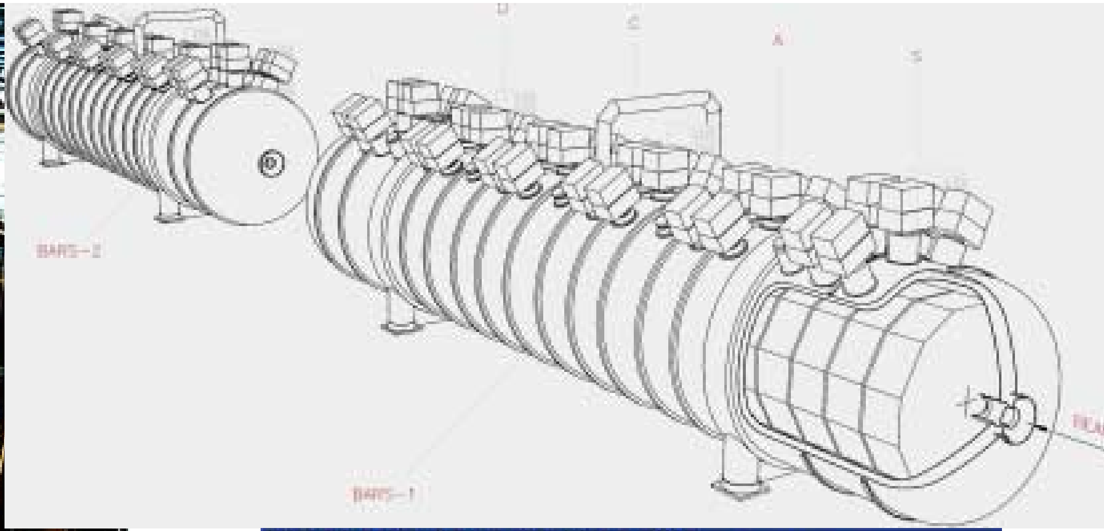


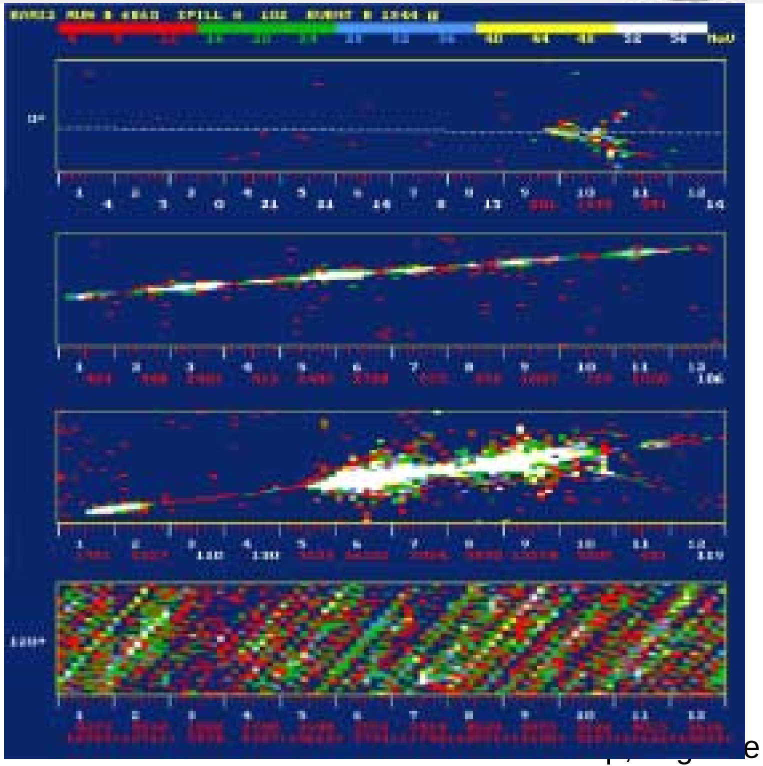
Broad Electromagnetic shower



Stopping muon decaying into electron (3 views)

BARS – 300 ton Liquid Argon Spectrometer





BARS

N·H
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Nuclear Instruments and Methods in Physics Research A 419 (1998) 596–601

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH
Section A

Use of the big liquid argon spectrometer BARS for neutrino and cosmic-ray studies[1]

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Abstract

The design of the fine grained 300 t liquid argon calorimeter BARS is described. The BARS electronics include about 30 K channels of low noise amplifiers and ADCs. The DAQ system makes it possible to select channels with signals above the chosen threshold. 48 scintillation hodoscopes placed inside the liquid argon are used to form the first level trigger. The total number of scintillation counters in liquid argon is 384. Sums of ionization signals are used to produce the second level trigger. Results of the first use of liquid argon calorimetry for the measurements of tagged neutrino interactions, cosmic-ray muon spectra and composition of extensive atmospheric showers are discussed.

Keywords: Liquid argon calorimeter; Tagged neutrino; Cosmic-ray muon

Magnetized Large Mass Liquid Argon Detector

- **Magnetic field insertion to TPC**
  - **High field (*B* = ~1 Tesla) – for electron charge discrimination**
    - **Use of superconducting magnets**
  - **Intermediate field (*B* = ~0.3 Tesla) – for muon momentum measurement**
    - **Use of conventional iron magnets**

- **A large mass (~100 kTon) for nucleon decay search?**
  - **70-kTon LANNDD at WIPP, New Mexico might be feasible.**
  - **Feasibility study is now underway.**

astro-ph/0301545

Study of the Backgrounds for the Search for Proton Decay to 10^{35}Y at the WIPP Site with the LANNDD Detector

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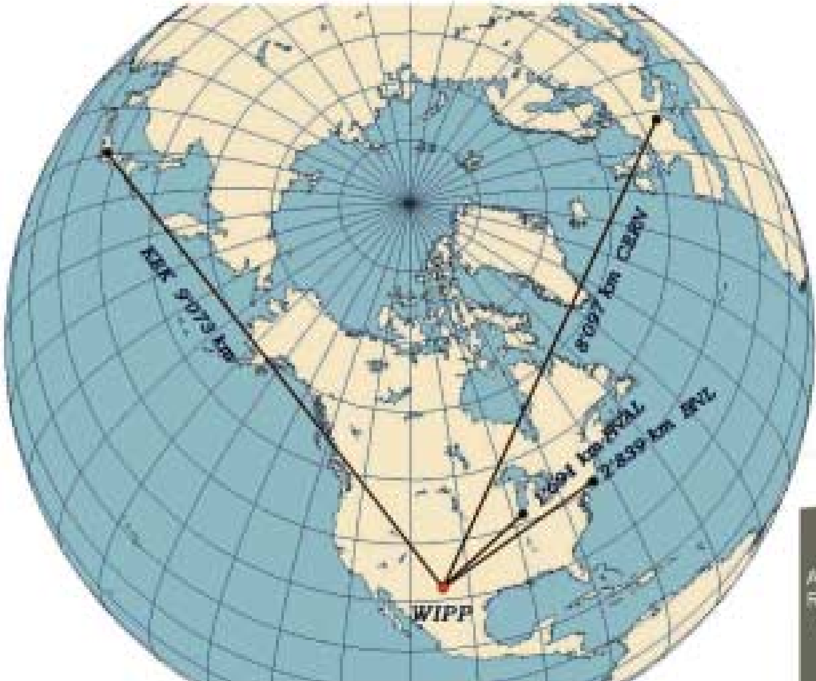
Abstract

We briefly describe the LANNDD 70-kT liquid argon TPC proposal for the WIPP underground facility at Carlsbad, New Mexico. We, then, identify the key backgrounds for the search for $p \to K^+\bar{\nu}$ to 10^{35} years lifetime. The most serious non-neutrino background is due to high-energy neutrons producing strange particles in the detector. We show that this can be reduced to an acceptable level by appropriate fiducial volume cuts.

Long Baseline Superbeams



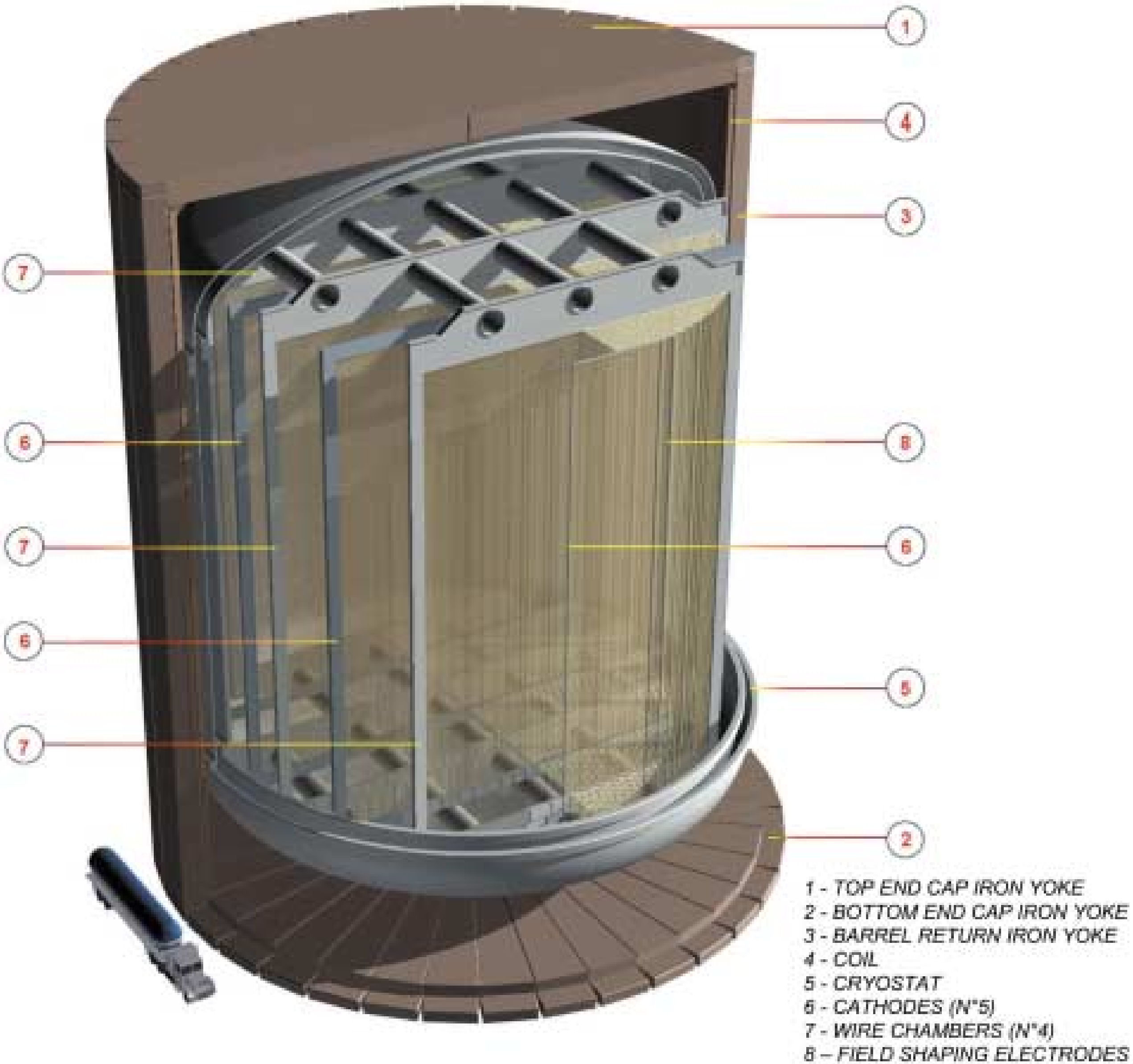
LBL Beam	Distance	θ_H	θ_V
FNAL	1691 km	47.9°	7.8°
BNL	2839 km	62.5°	12.9°
CERN	8097 km	41.6°	39.5°
KEK	9073 km	-44.7°	45.4°

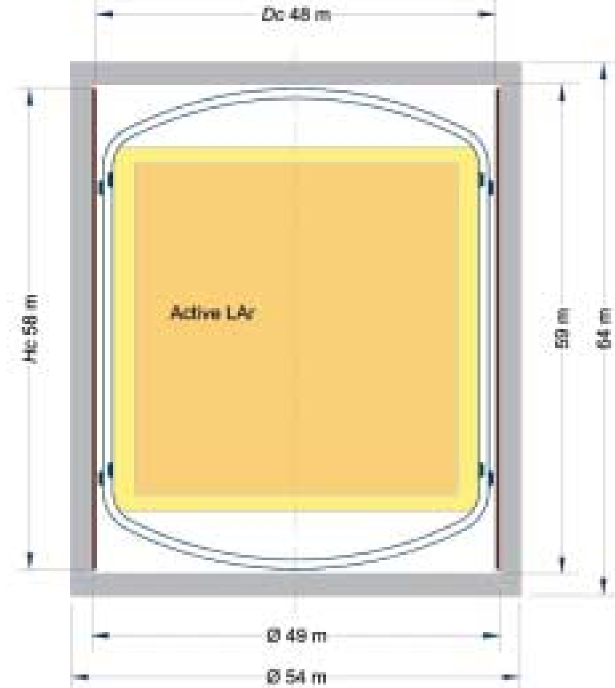
θ_H: angle, in the WIPP site horizontal plane, respect to the NORD

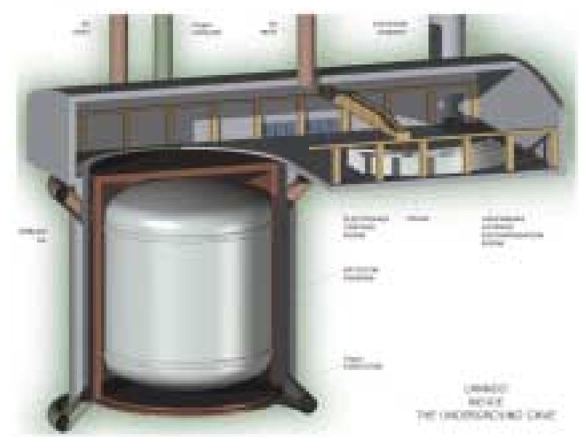
θ_V: angle at the WIPP site, respect to the horizontal plane

WIPP Underground Laboratory at Carlsbad, NM

LANNDD 70kT


1
4
3
7
6
8
7
6
6
5
7
2
1 - TOP END CAP IRON YOKE
2 - BOTTOM END CAP IRON YOKE
3 - BARREL RETURN IRON YOKE
4 - COIL
5 - CRYOSTAT
6 - CATHODES (N°5)
7 - WIRE CHAMBERS (N°4)
8 – FIELD SHAPING ELECTRODES


Dc 48 m
Active LAr
Hc 58 m
59 m
64 m
Ø 49 m
Ø 54 m



Mini-LANNDD T40

astro-ph/0301545

Mini-LANNDD T40: A detector to measure the neutrino-argon cross section and the ν_e contamination in the off-axis NuMI beam

David B. Cline[a], Youngho Seo[a], and Franco Sergiampietri[a,b]

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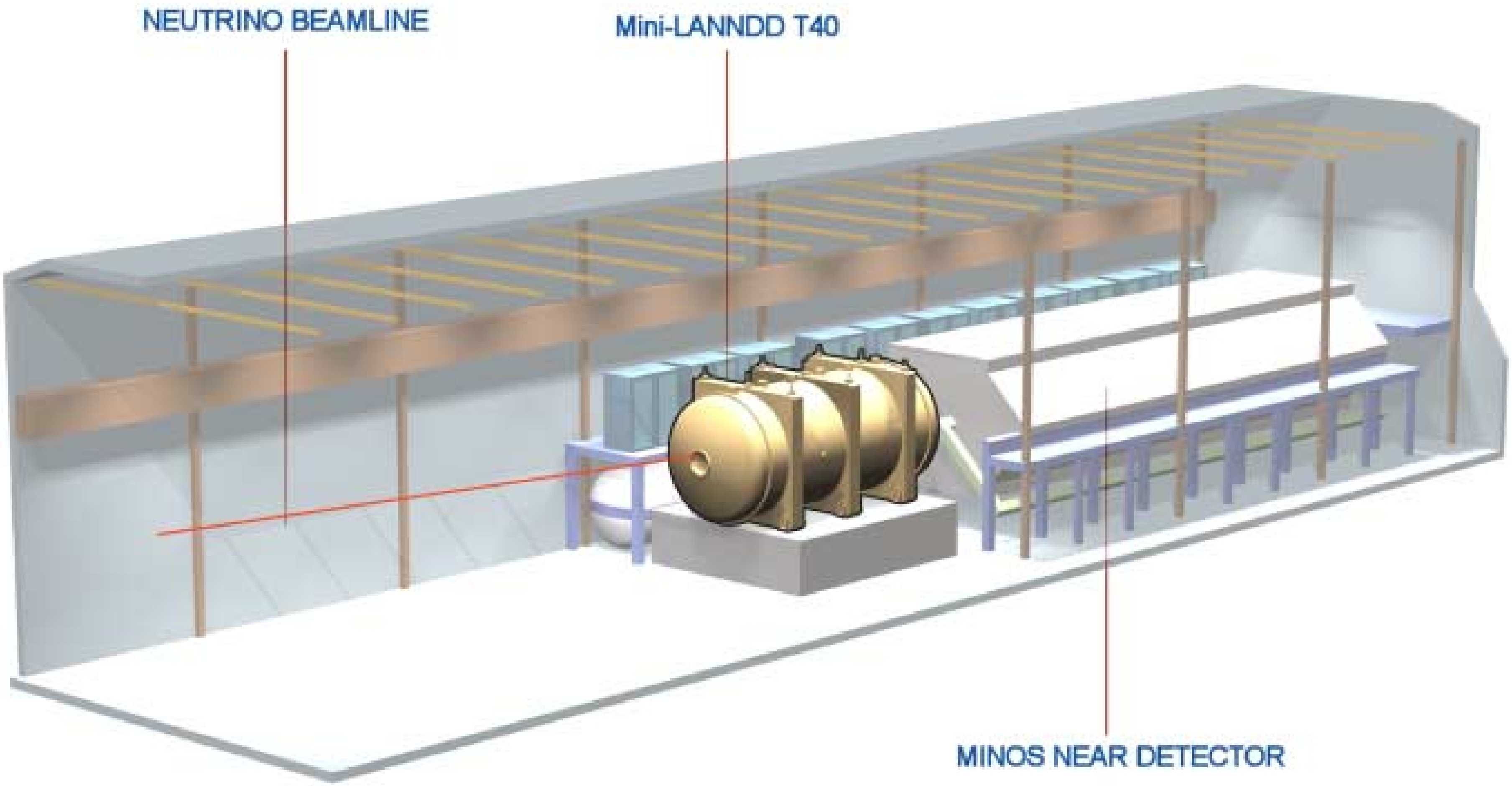
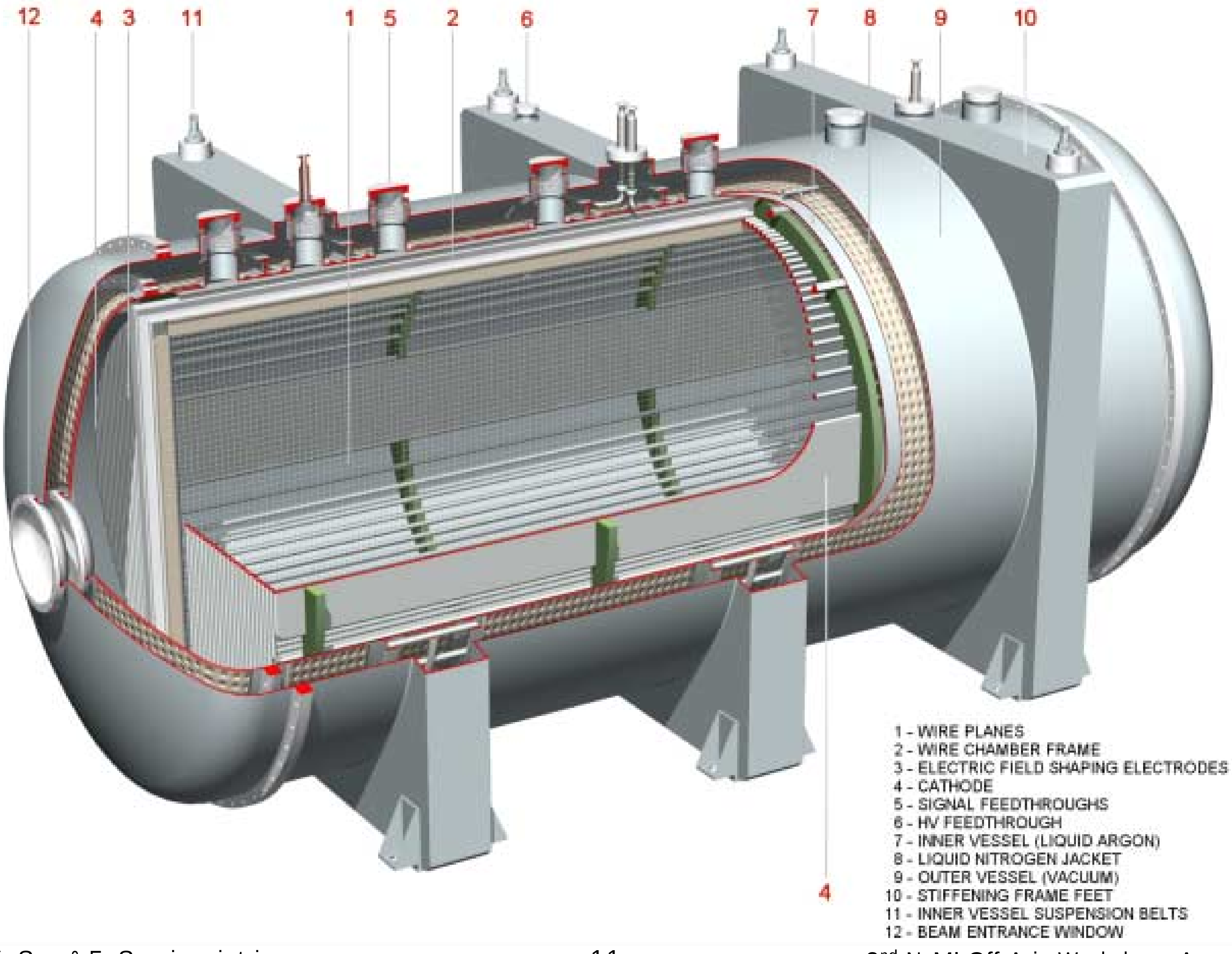
Abstract

We describe a preliminary study of a 40-ton liquid argon TPC based on the ICARUS method to use in the NuMI near region in line with the LANNDD project [1,2]. This reduced-scale detector, called "Mini-LANNDD T40", is designed for R&D purposes and systematic measures on its response. Safety concerns are a key issue, which will be discussed as well as a preliminary design of the detector. Adapted as a near or vertex detector in a neutrino beam, the Mini-LANNDD T40 is capable of observing the ν_e flux in the off-axis beam, a key to use for measuring $sin^2 2\theta_{13}$ in the future, and measuring the low energy neutrino-argon cross-section, an important piece of information for future long baseline experiments.

Mini-LANNDD T40 at NuMI Near Hall



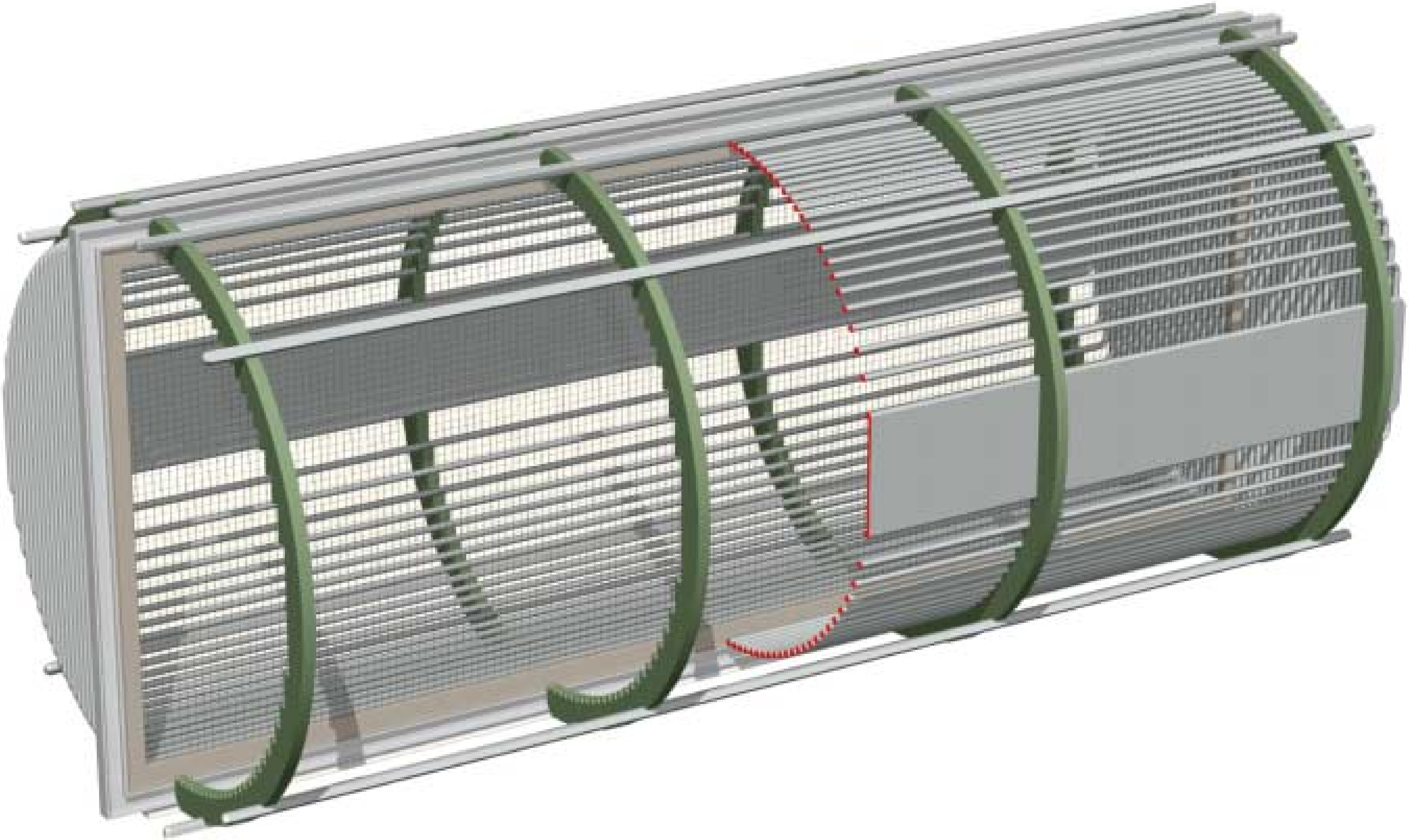
Mini-LANNDD T40: The Detector



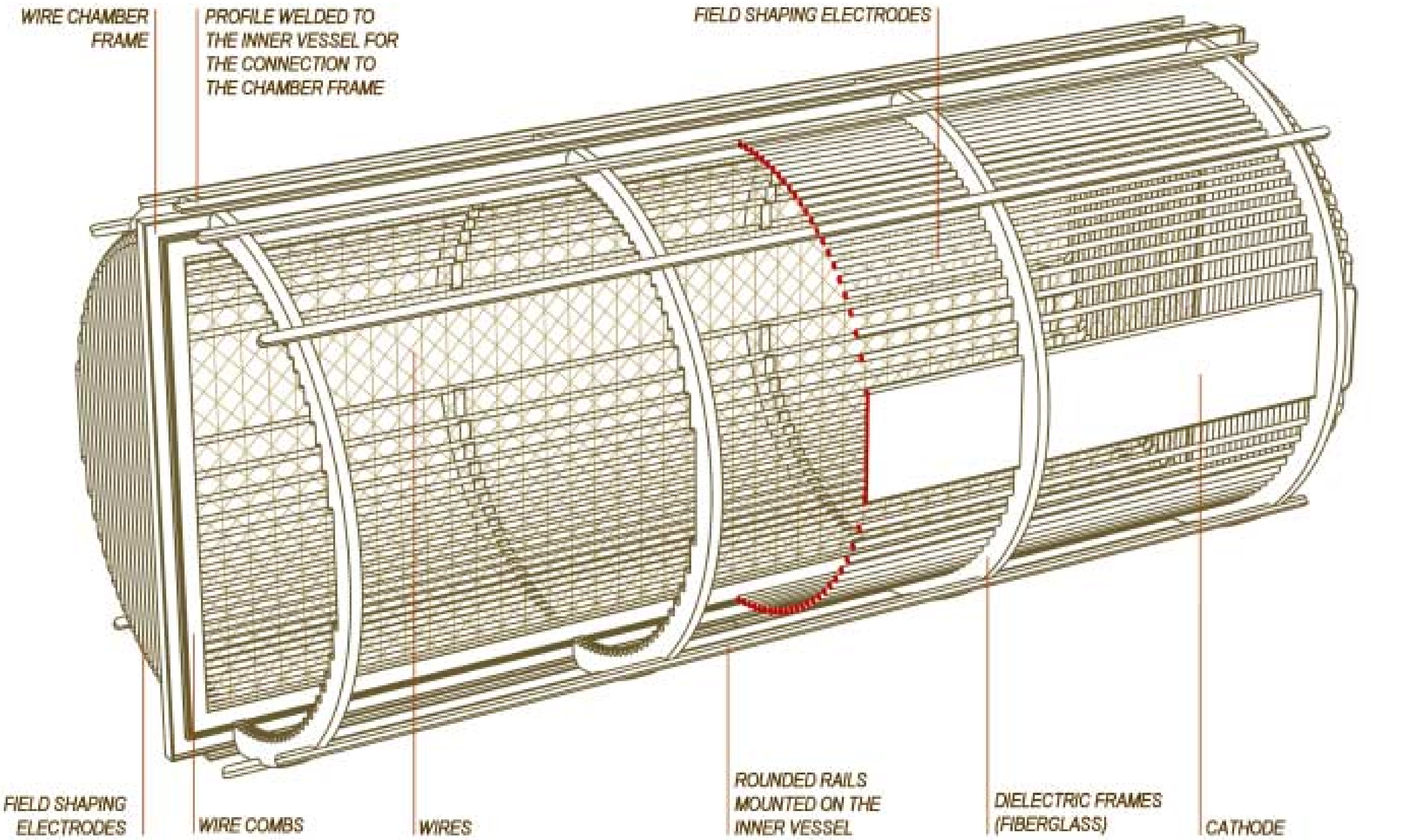
Mini-LANNDD T40 Key Parameters

Total liquid argon volume	**42.8 *m^3***
Gas argon volume	**0.9 *m^3***
Active liquid argon volume	**27.7 *m^3***
Active liquid argon sizes	**W (= 2.4 *m*) × H (= 2.3 *m*) × L (= 6.0 *m*)**
Active liquid argon mass	**38.5 *Ton***
Number of drift regions	**2**
Drift lengths	**2 × 1.2 *m***
Maximum required high voltage	**60 *kV***
Number of cathode planes	**2**
Number of HV feedthroughs	**1**
Number of wire chambers	**1**
Number of readout wire planes	**4**
Orientation of readout wires	**0°, 90°**
Number of readout wires	**5,632**
Number of signal feedthrough chmneys	**6**
Number of analog-to-digital procession crate pairs	**10**
Heat Input *a)* Radiation (with $w_r = 1$ *watt/m^2*)	**95 *W***
b) Conduction (cables & mech. supports)	**210 *W***
Total	**305 *W***
Equivalent liquid nitrogen consumption	**0.2 *m^3/d***

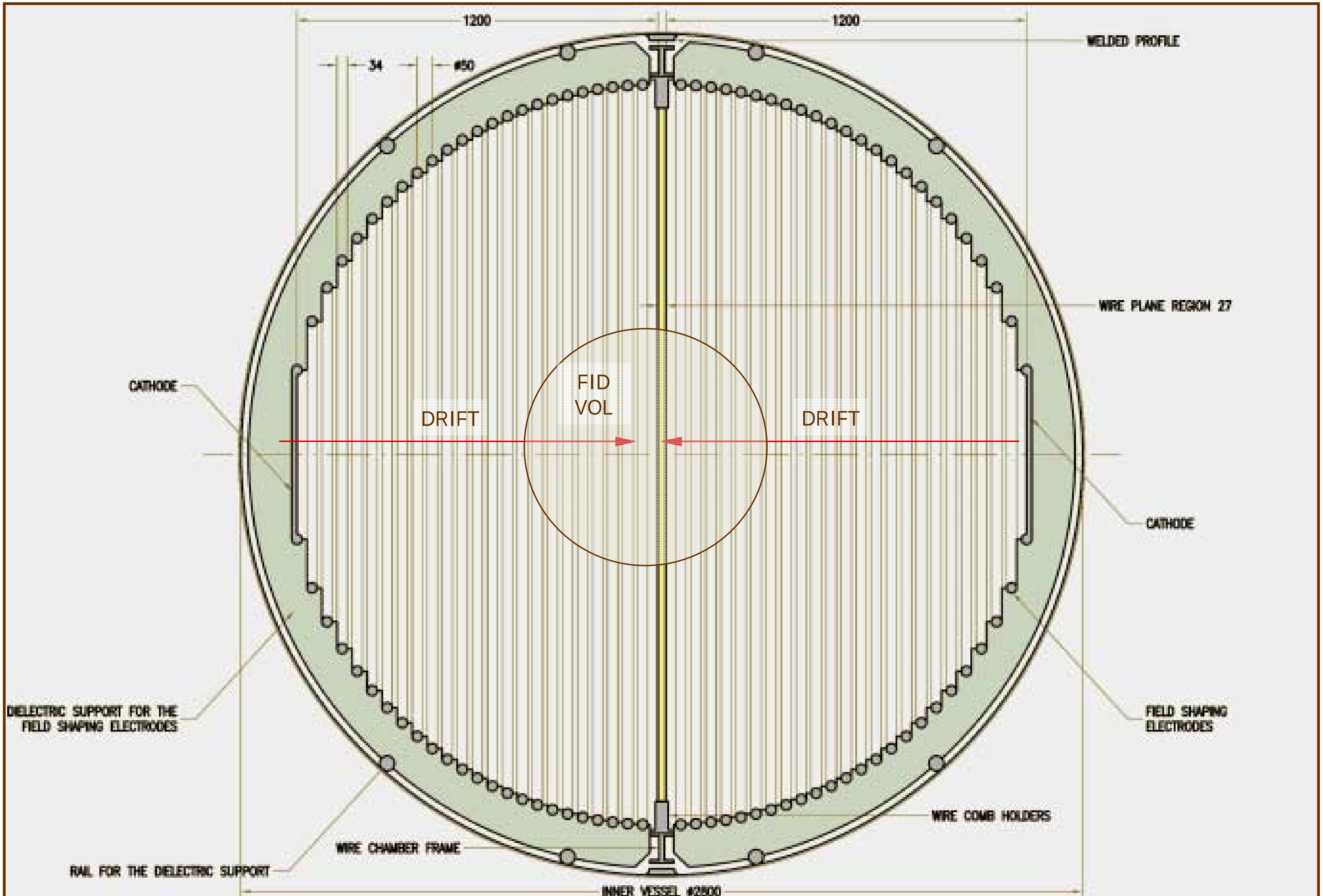
Mini-LANNDD T40: The TPC



Mini-LANNDD T40: The TPC



Mini-LANNDD T40: The TPC – Transverse Cross-section



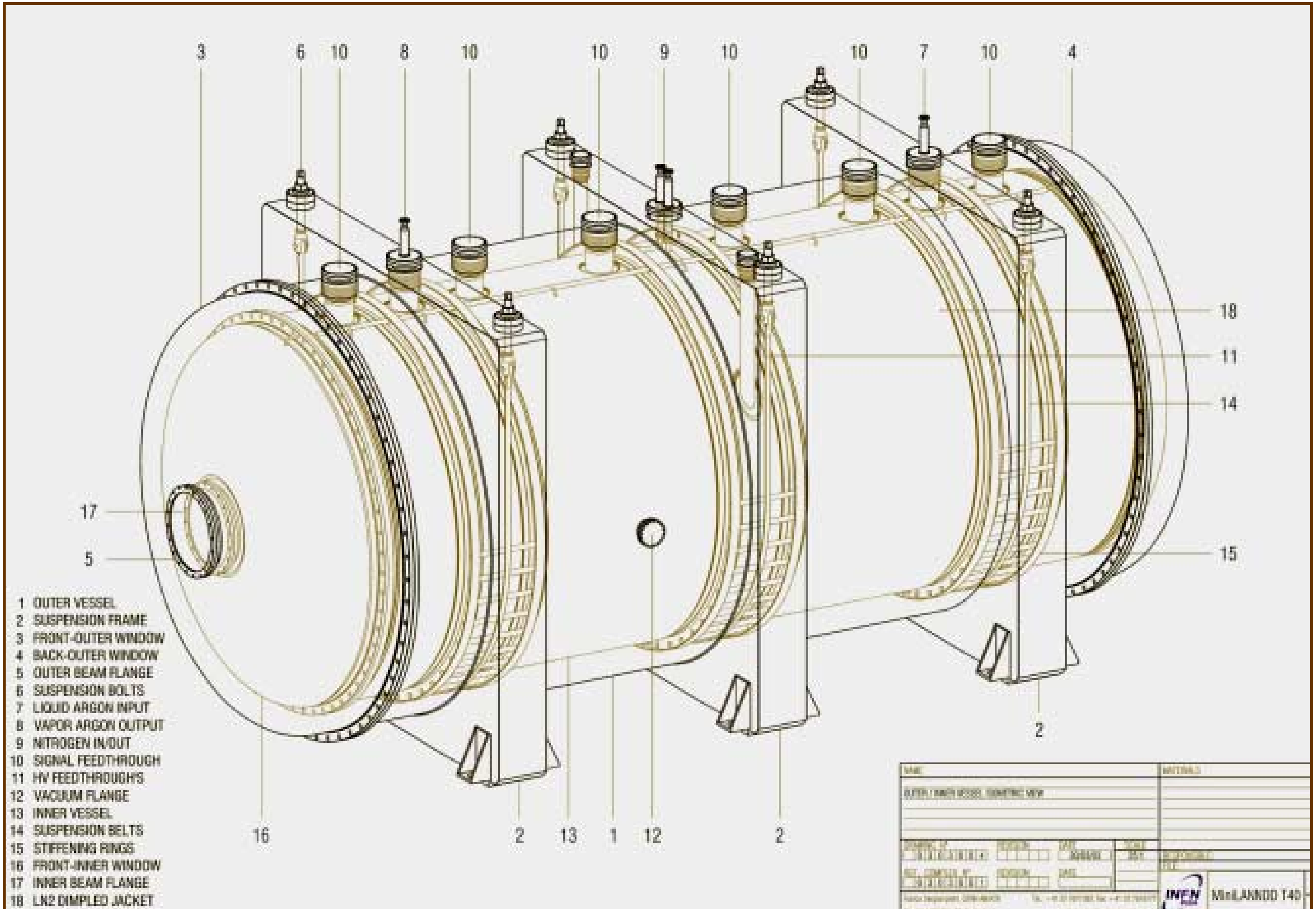
Key Technical Details for LAr TPC

- **Cryostat**

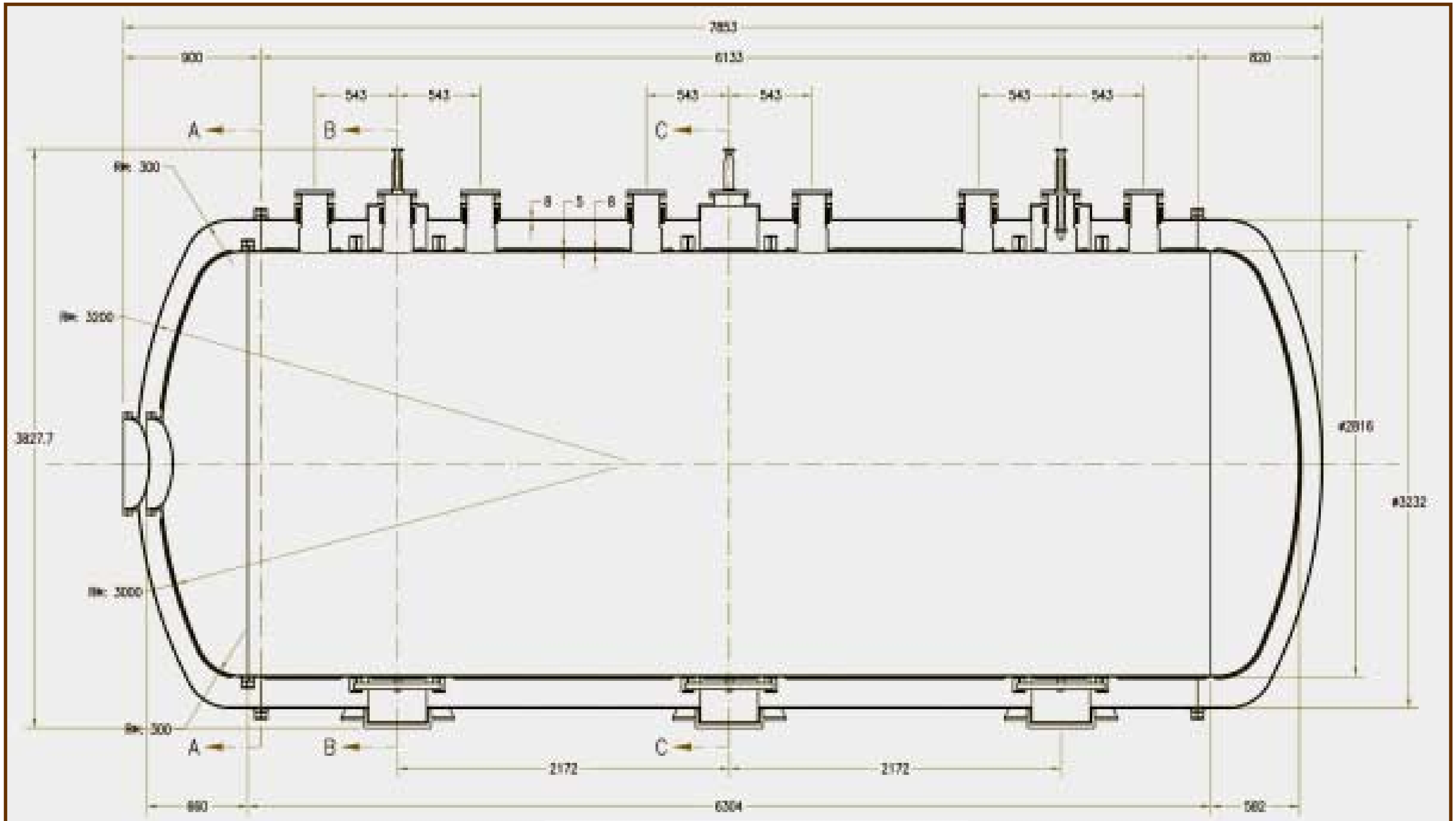
- **Wire chamber**

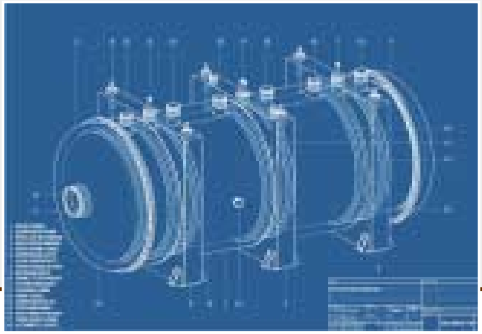
- **Charge drift over some meters**

T40: The Cryostat

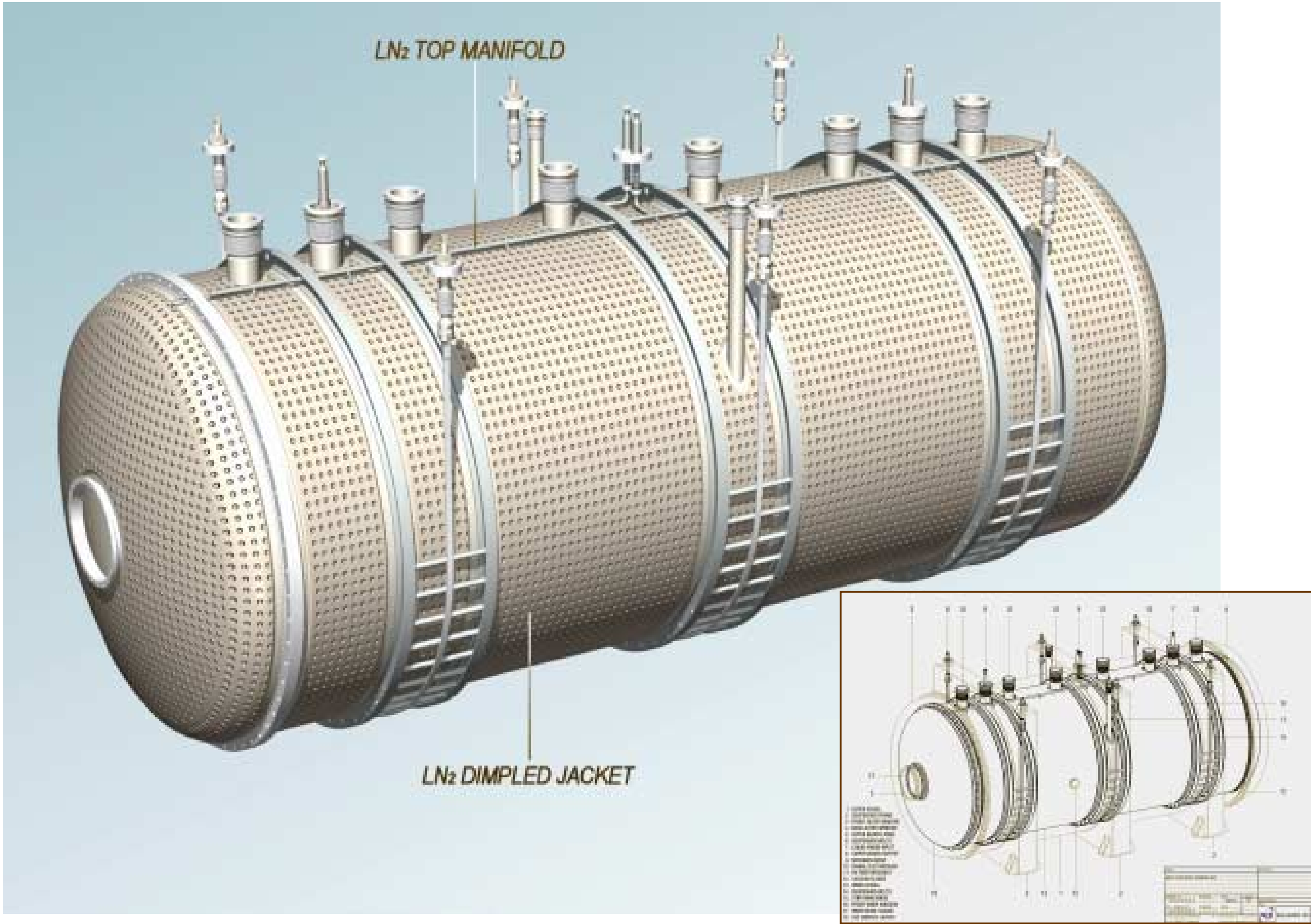


The Cryostat: Vertical Cross-section

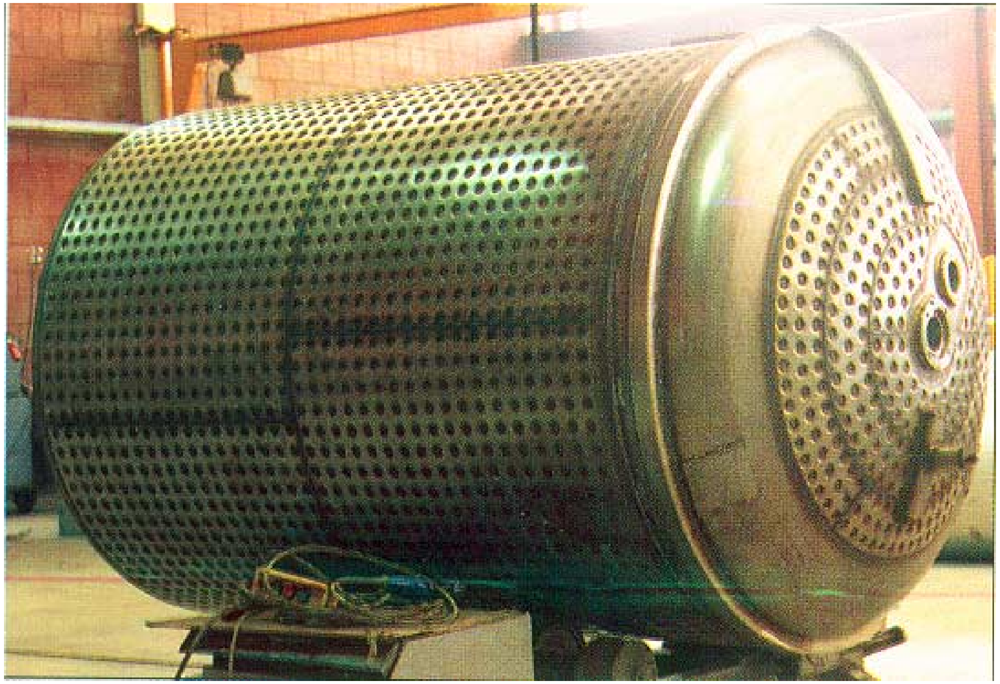


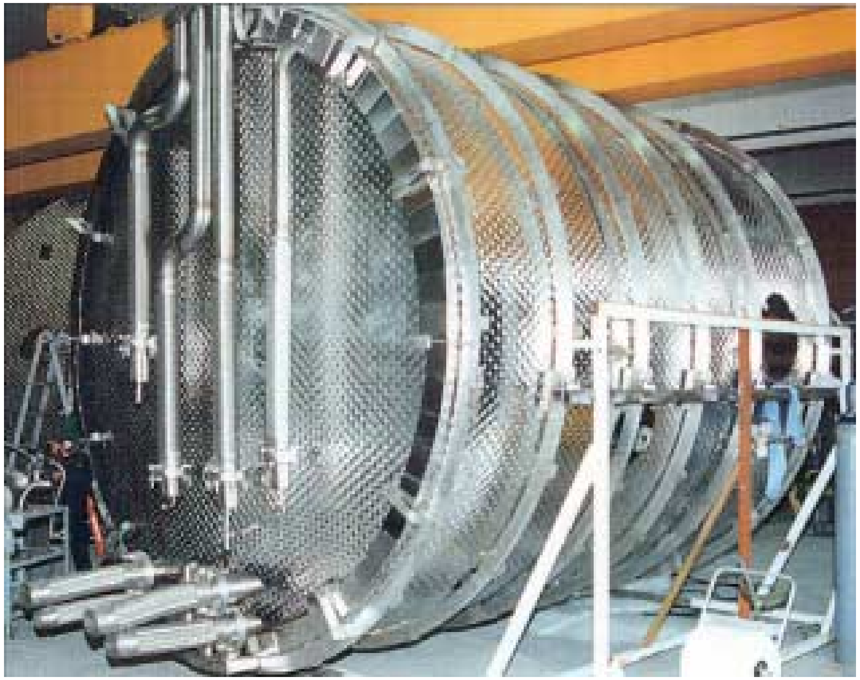


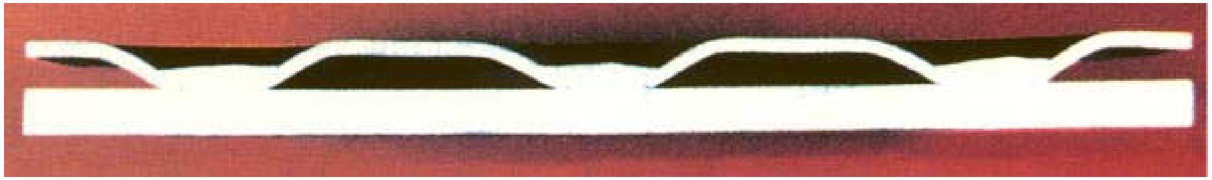
Cryostat – Inner Vessel and Heat Exchanger



Cryostat – Heat Exchanger Technology

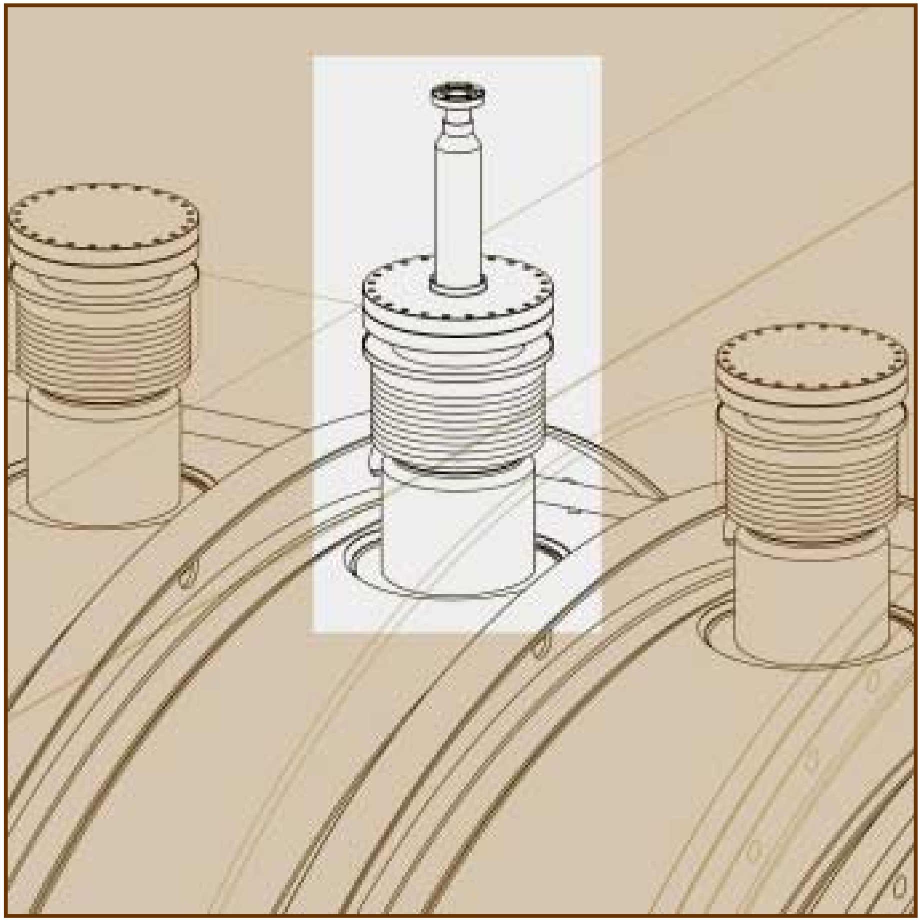


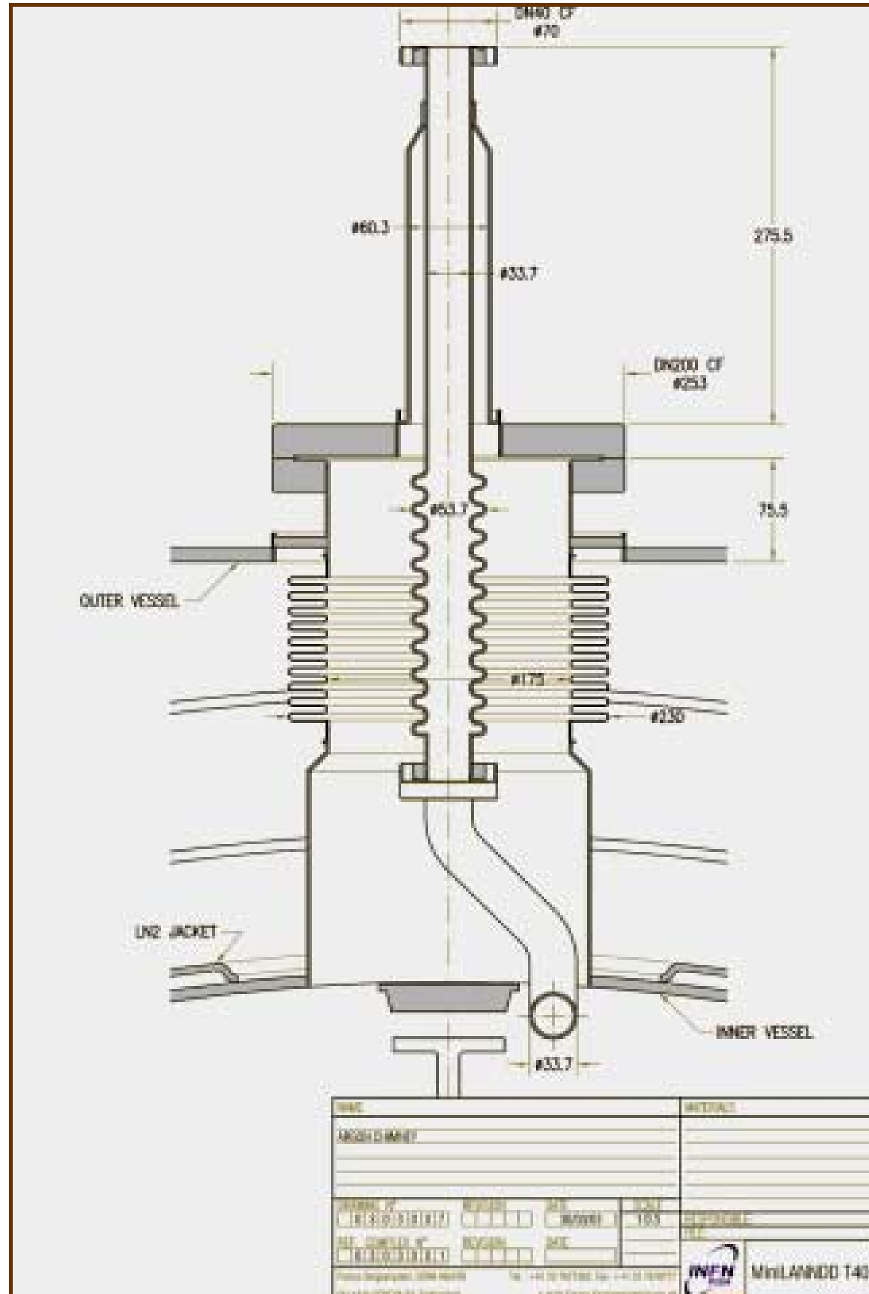




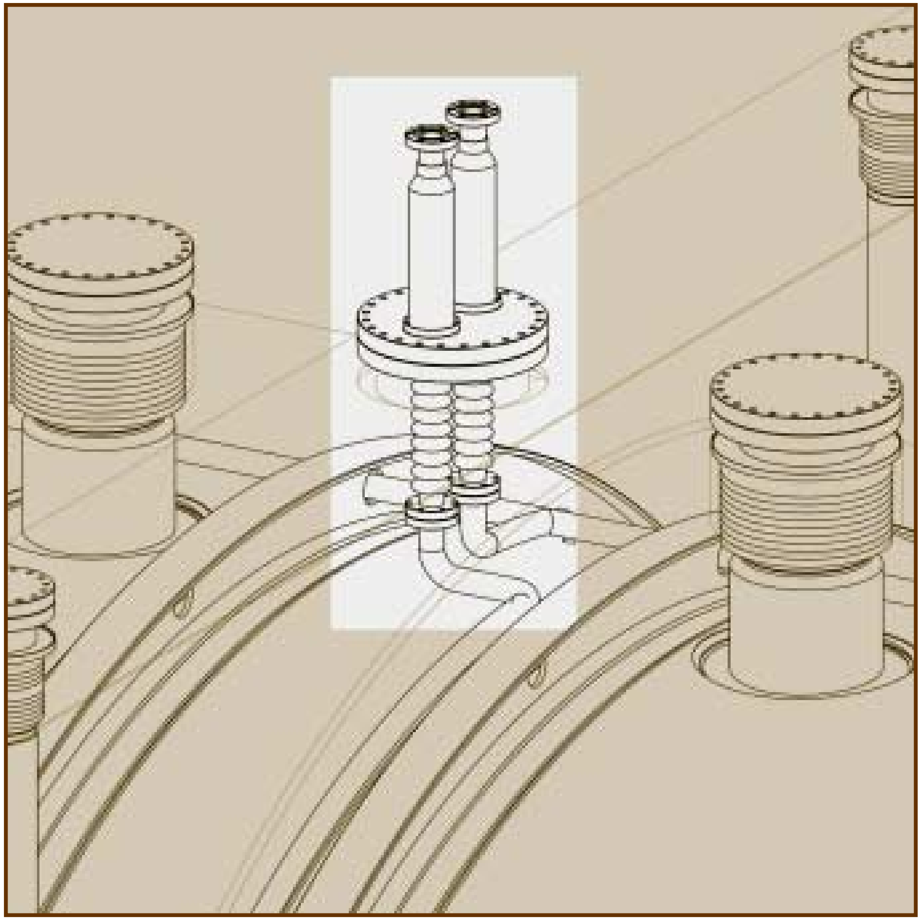
Fabricated by welding a pre-deformed plate to a flat plate. The dimpled plate is pre-deformed with different shapes, to obtain an air space varying from 3 to 15 mm between the plates. The welding can be made by MIG, TIG or Resistance Spot process. No limitation on the thickness plates used.

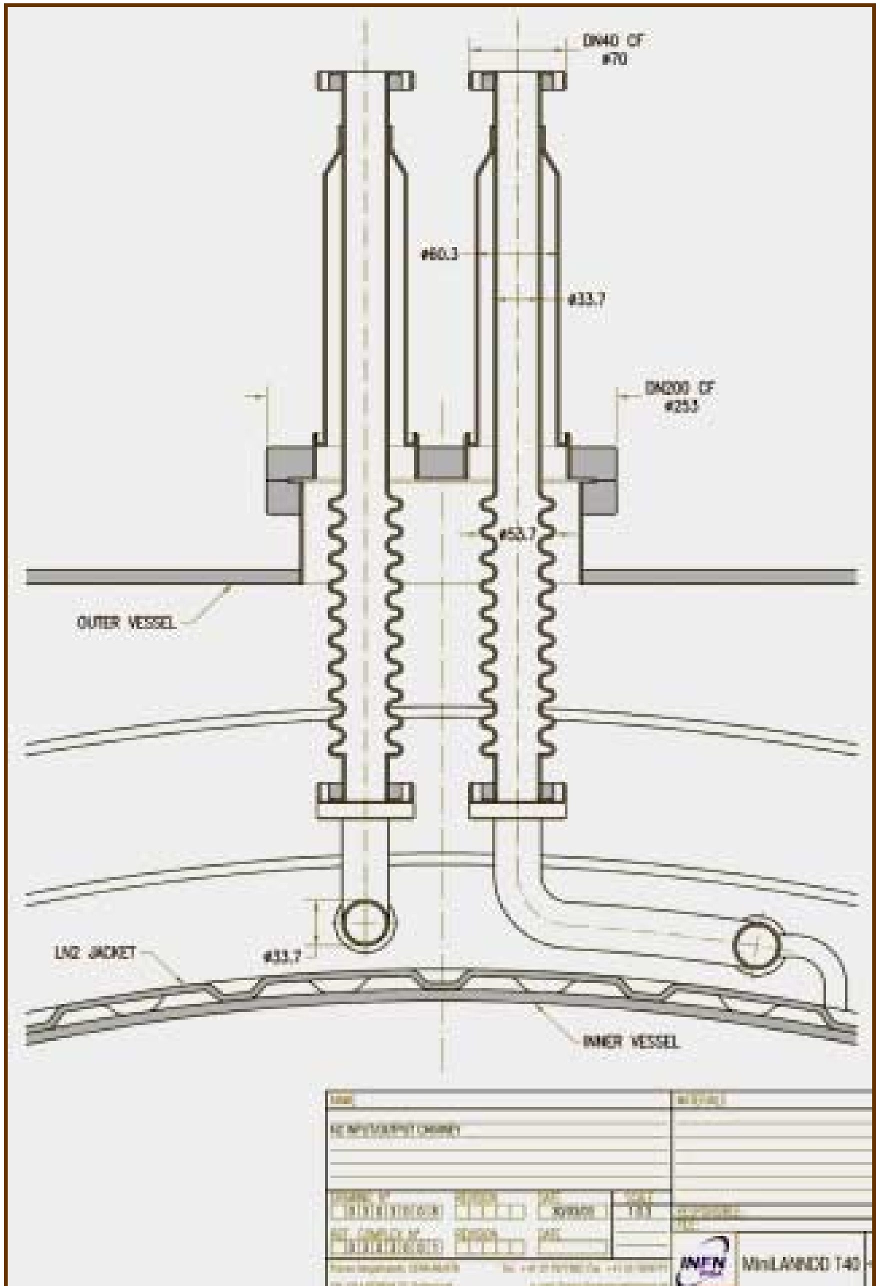
Cryostat: Argon Chimney



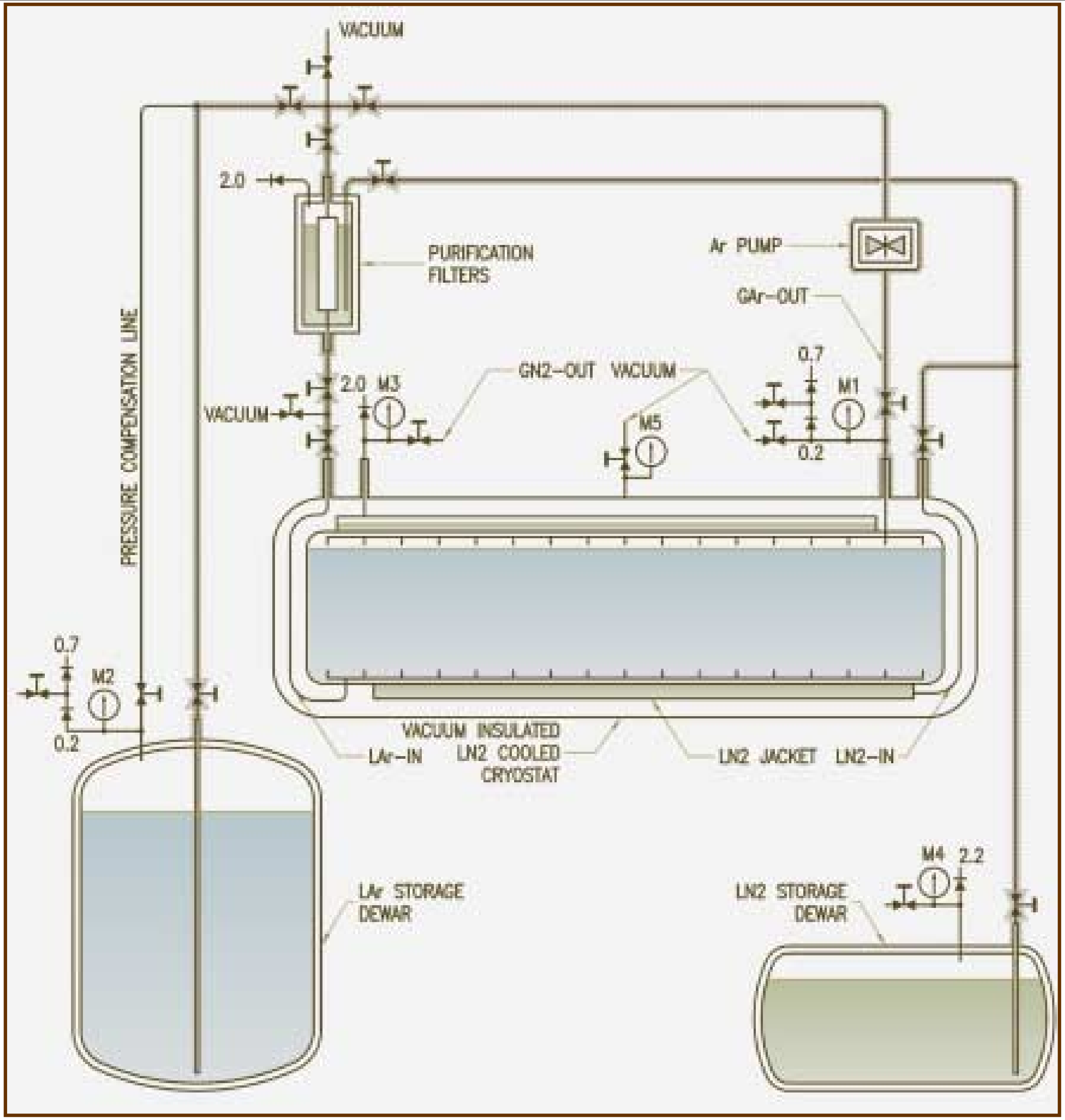


Cryostat: LN_2 Chimney

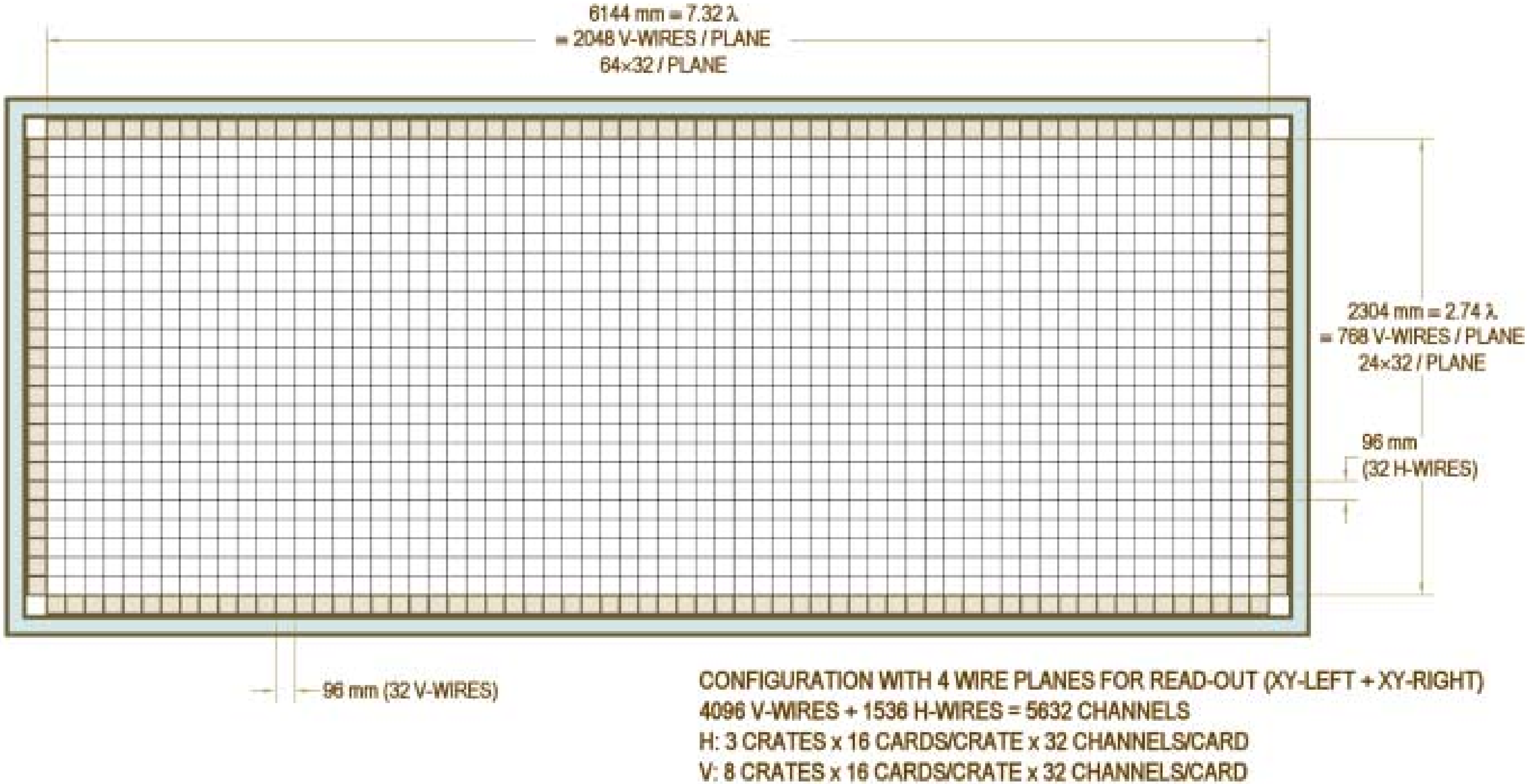




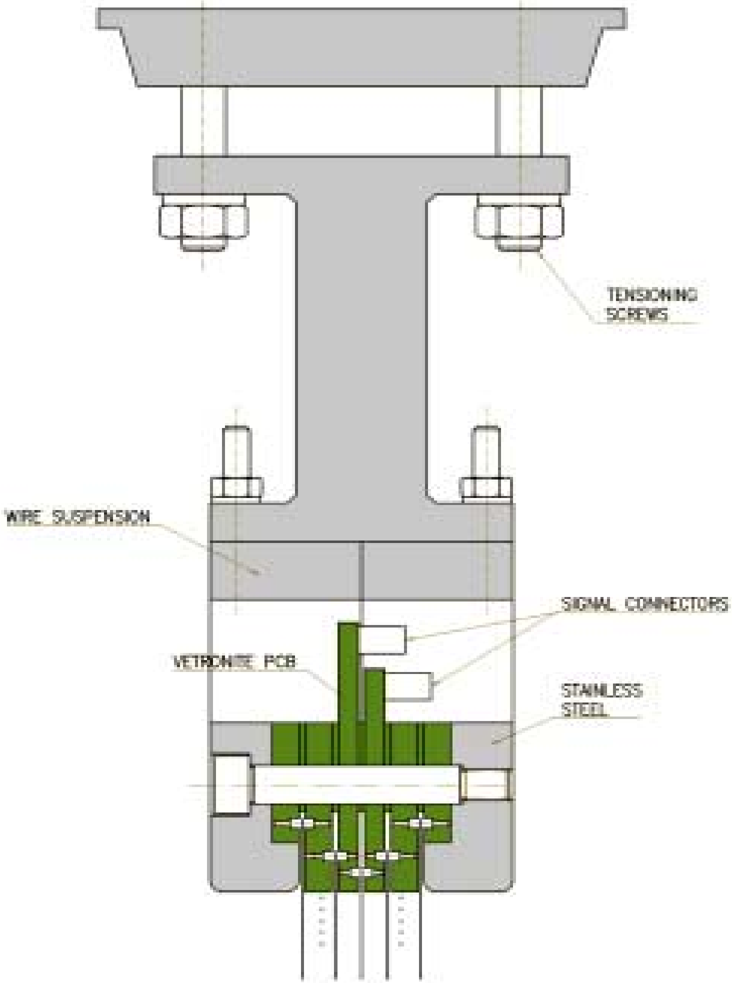
Simplified Cryogenic Scheme

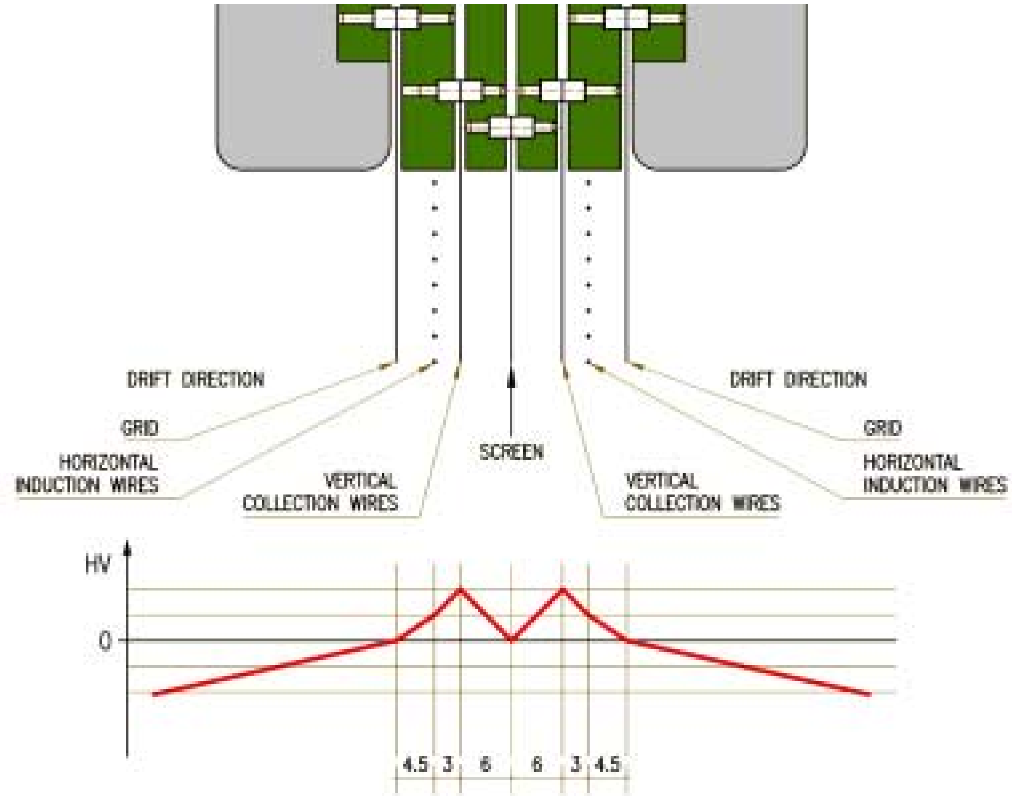


Wire Chamber



Wire Hanging





Stainless steel wires with ∅100 μm at a 3 *mm* pitch.

Channel maximum capacitance in LAr:
23 *pF/m* × 40 *m* + 2 *m* Cable ≈ 1 *nF*
ENC ≈ 1600 e^- RMS, *S/N* ≈ 8-10 for minimum signals

With E_{drift} = 0.5 *kV/cm*, 7 wire planes:

- 2 grid planes + 1 screen plane made by vertical wires referred to ground
- 2 induction planes with horizontal wires biased at +337.5 *V*
- 2 collection planes with vertical wires biased at +675 *V*

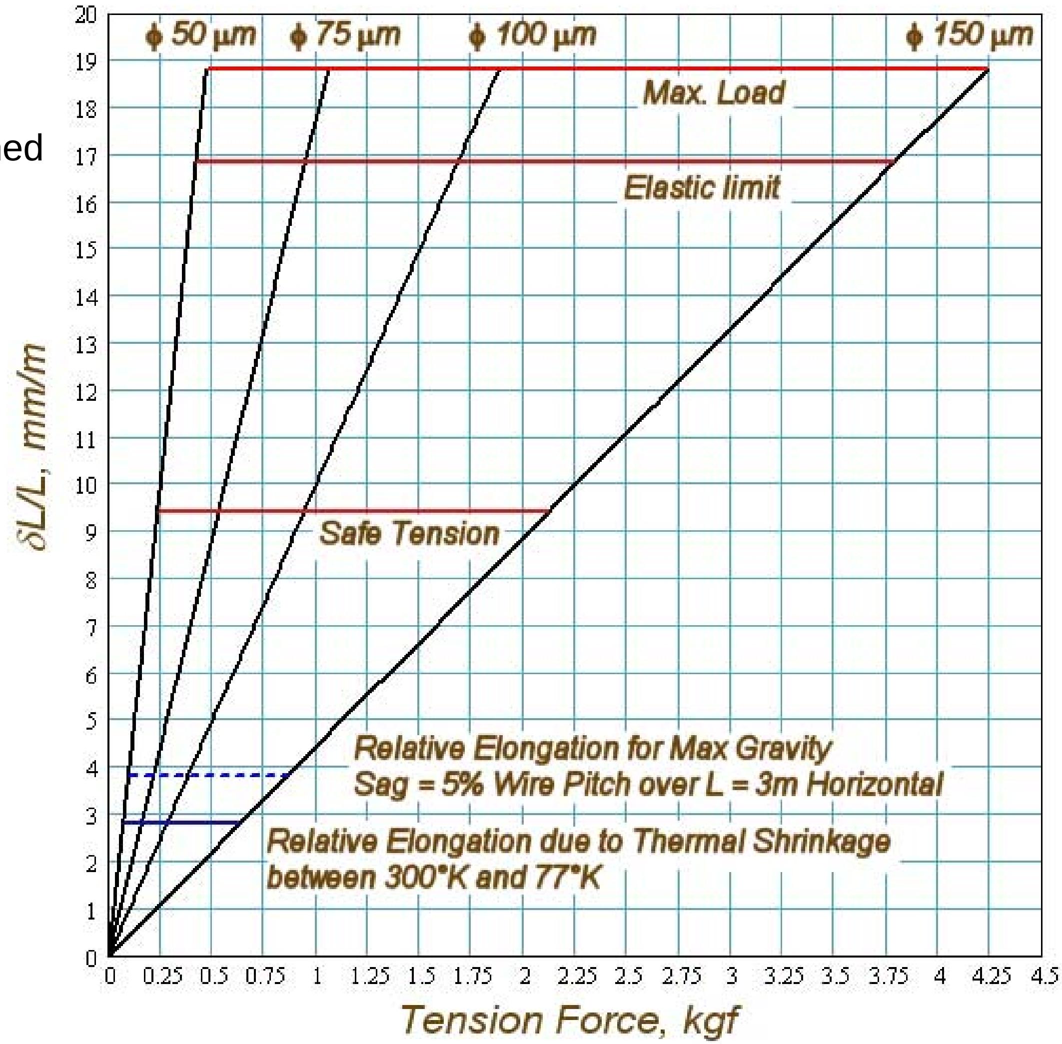
Wire Tension

WIRE MATERIAL

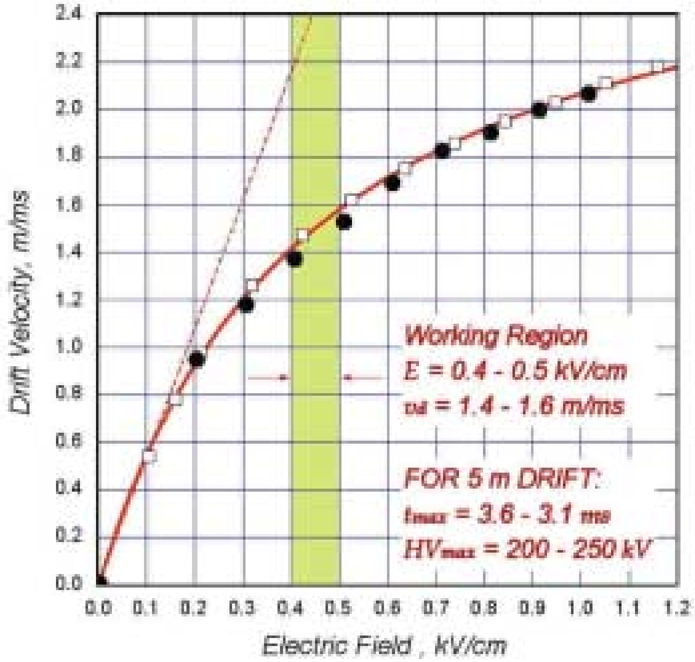
AISI 302 Stainless Steel, 4/4 hard drawn, polished

Max. Load $R_m = 2350\ N \cdot mm^{-2}$

Elastic Limit $R_{p0.2} = 2100\ N \cdot mm^{-2}$

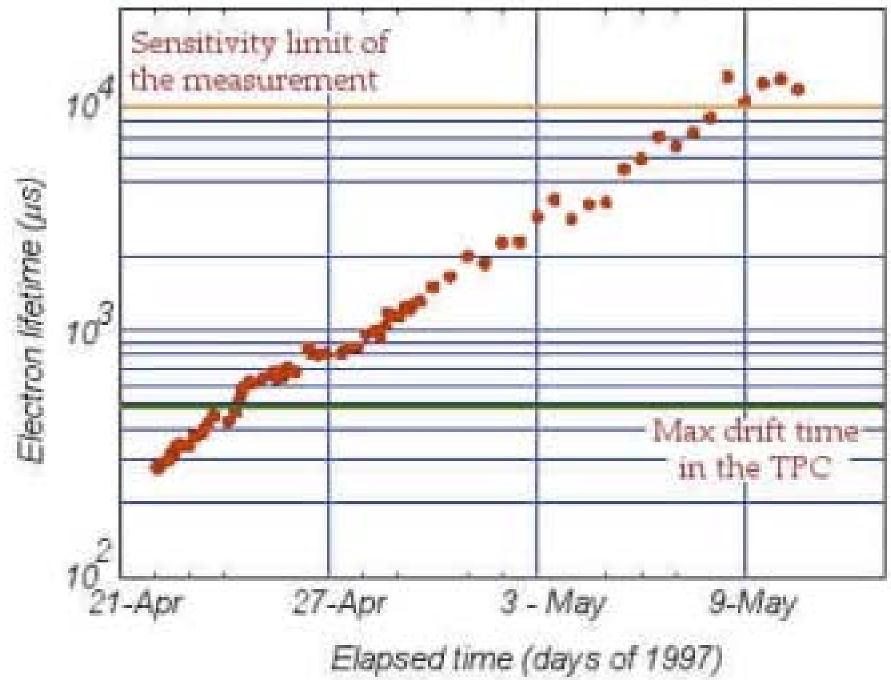


Charge Drift in Liquid Argon



Drift velocity versus electric field in liquid argon

(data from ICARUS R&D and ICARUS T600)



Purification rate

(Data from ICARUS R&D)

HV Feedthroughs

HV System for a Long Charge Drift

Mini-LANNDD T40 Rough Cost Estimate (without Magnet)

Liquid argon	60 m^3	**30 *k$***
Cryostat	Inner vessel LN_2 jacket Outer vessel Beam entrance windows Thermally decoupled chimneys for signals, HV, IN/OUT *Ar*, IN/OUT LN_2, inner vessel suspension	**500 *k$***
Inner detector mechanics and wiring	Wire chamber (frame, wires, combs, and spacers) Field shaping electrodes and cathodes	**70 *k$***
Electronics (5,632 channels) and DAQ	Signal cables and feedthroughs Analog and Digital Processing crates Calibration pulser and Wire bias HV power supplies Acquisition and event display computer	**350 *k$***
Vacuum & cryogenic components	Vacuum pumps and gauges LN_2 and *LAr* storage dewars *LAr* purification system and purity monitor Transfer lines, valves Level and temperature monitors	**75 *k$***
High voltage system	Power supply, feedthrough, monitor	**25 *k$***
Other details & contingency	External trigger counters and electronics UPS and O_2 monitors	**150 *k$***

Total: 1200 *k$*

Concluding Remarks

- **In order to realize a large size (~100 kT) liquid argon TPC for nucleon decay or as an end detector with future superbeam from BNL or FNAL,**
  - **The study of a smaller-scale detector such as Mini-LANNDD T40 presented here is a good start for future neutrino detector development programs.**
- **NuMI on-axis/off-axis beam gives a good opportunity to place an inexpensive, but interesting-physics-capable detector in the near future.**
  - **Firm cost estimates for T40 (or such size liquid argon TPC) will come soon collaborating with our UCLA group.**
- **As an electron-neutrino detector, the key size required is for the vertex, and two radiation lengths to identify the event. A small fiducial volume can be used to measure the energy spectrum.**
  - **The size of T40 is sufficient to do this physics.**
- **A long charge drift (~5 m) test is being planned at UCLA using the shown HV feedthrough that is being used by the ICARUS collaboration.**